(12) UK Patent Application (19) GB (11) 2 208 896 (13) A

(43) Date of A publication 19.04.1989

(21) Application No 8819460.0

(22) Date of filing 16.08.1988

(30) Priority data
(31) 087097 (32) 19.08.1987 (33) US

(51) INT CL⁴
F04B 43/12

(52) UK CL (Edition J)
F1U UA U3 U6
U1S S1067

(56) Documents cited
GB 2190145 A GB 2109474 A US 4599055 A

(58) Field of search
UK CL (Edition J) F1U UA
INT CL⁴ F04B

(71) Applicant
Cobe Laboratories Inc

(Incorporated in the USA - Colorado)

1201 Oak Street, Lakewood, Colorado 80215, United States of America

(72) Inventors
Marlene Adele Bainbridge
Charles Bowden Powell
Philip Michael Finsterwald

(74) Agent and/or Address for Service
Lloyd Wise Tregear & Co
Norman House, 105-109 Strand, London, WC2R 0AE, United Kingdom

(54) Peristaltic pump cartridge

(57) The cartridge 54 includes a continuous flexible tube 56 having two ends and a portion therebetween providing a U-shaped loop for use with a pump unit 30 comprising a rotor 28 and rollers (84, Figs. 6 & 7), to provide a peristaltic pump assembly. The cartridge housing has supports (46, Fig. 2) for maintaining the portion of the flexible tube in the U-shaped loop external to the housing with the legs of the U-shaped loop leading into the housing. Two flexible tubes 56, 58 are provided in each cartridge. The cartridge housing has several apertures through which the two connecting portions of each flexible tube remote from the U-shaped loop can pass in various arrangements. Loading and unloading of an external U-shaped loop to an associated pump unit 30 is facilitated by a rotary domed cap 72 having guiding ribs 76 and a displacement tab 74 thereon. Locating tabs (64) are provided on a side wall of the cartridge housing to facilitate its assembly to the pump unit.

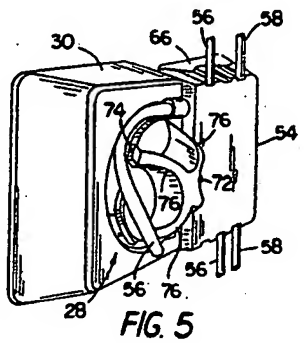

FIG. 5

GB 2 208 896 A

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

2208896

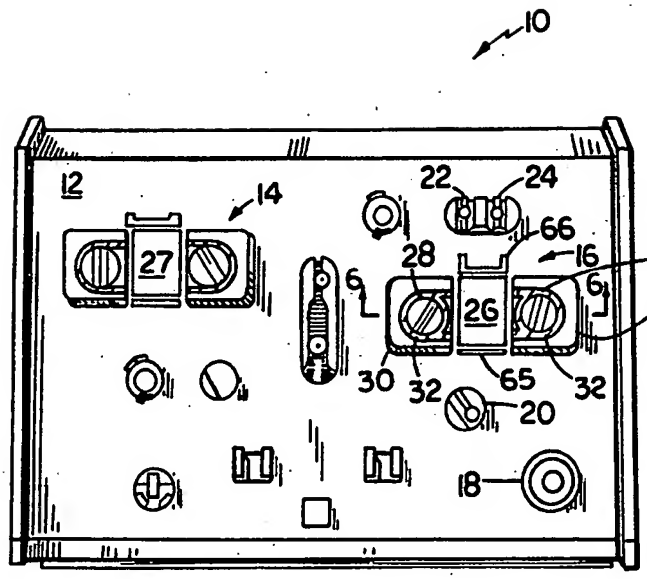

FIG. 1

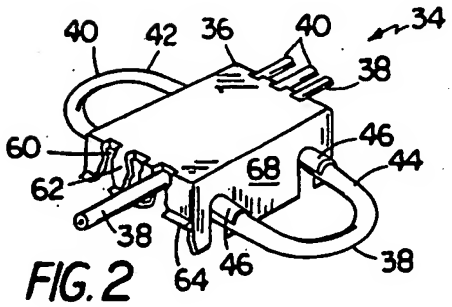

FIG. 2

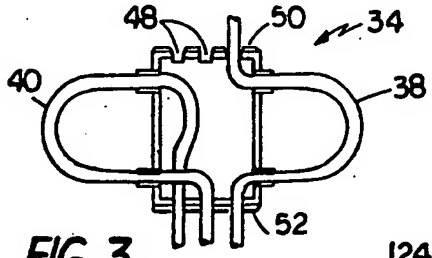

FIG. 3

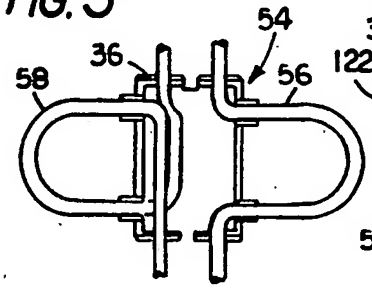

FIG. 4

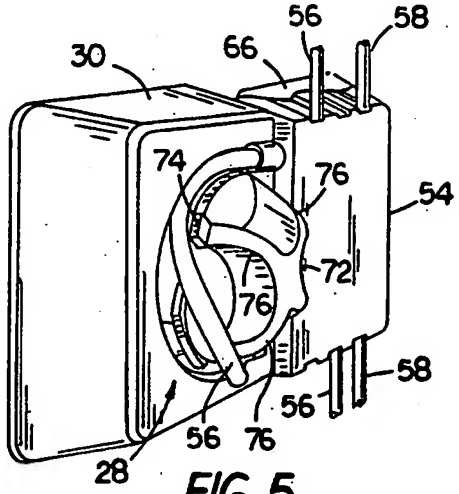

FIG. 5

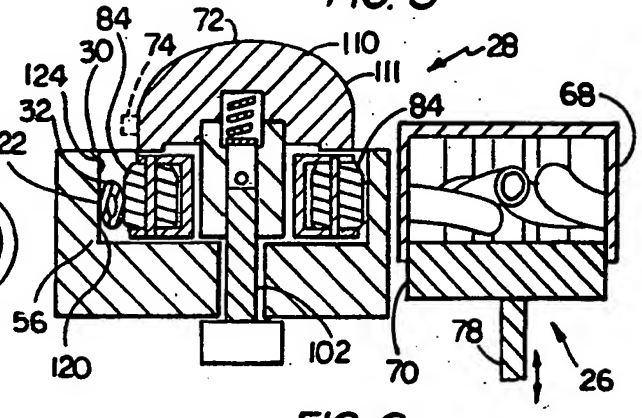

FIG. 6

2208896

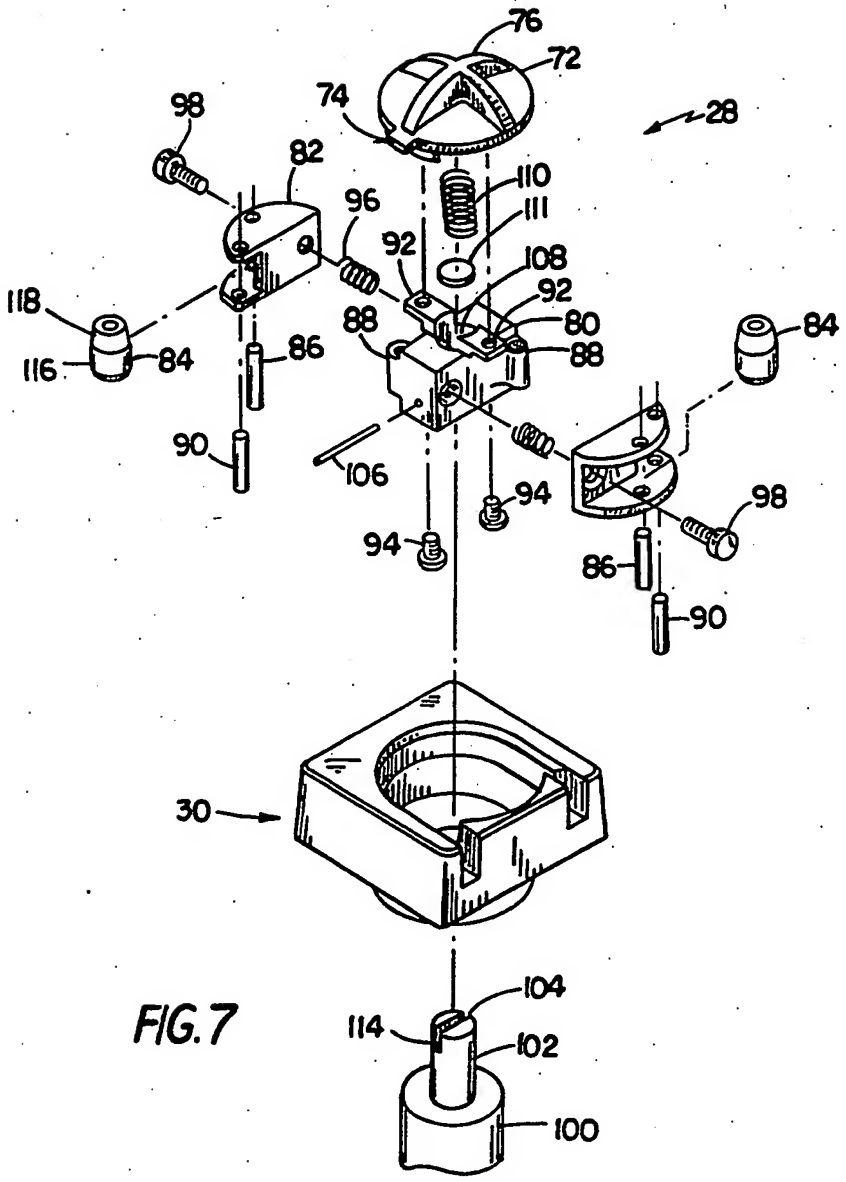

FIG. 7

2208896

PERISTALTIC PUMP CARTRIDGE

The invention relates to cartridges used in peristaltic pumps.

In one type of peristaltic pump, a flexible tube is compressed between rollers that are carried by a rotor and travel along a circular path and a race that has a surface adjacent to and concentric with the path of the rollers. As the occluded portion of the tube is advanced, the fluid in front of it is forced to travel through the tube.

A use of such a pump is in extracorporeal blood treatment. The peristaltic pumps have been provided on the front panel of a blood processing machine, employing flexible tube portions of a disposable tubing set that is changed for use with a different donor/patient. Some tubing sets have included cartridges that are removably mounted on the machine and carry flexible tubes in position to be acted upon by pump rollers on the front panel of the machine, e.g. DeVries U.S. Patent No. 4,379,452; published European Patent Application 0,134,436; British Patent Application 8615491 (published under No. 21767171A) and British Patent Application No. 8707228 (published under No. 2190145A).

In our British Patent Specification 2190145 patent we describe a pump that self-loads a flexible tube portion placed in a tube mounting region adjacent to a tube pumping region between the race and the rollers, as the rollers rotate owing to the action of a small diameter roller portion adjacent to the tube mounting region and a large diameter roller portion adjacent to the tube pumping region. When unloading the tube from the pump, a lifter arm extending from a movable cover lifts the tube out of the tube pumping region as the cover is moved away from the pump.

In accordance with the present invention, we provide a peristaltic pump cartridge comprising: a continuous flexible tube having two ends and a portion therebetween providing a U-shaped loop for use with a rotor and rollers to provide a peristaltic pump, a cartridge housing having supports for maintaining said portion of said flexible tube in said U-shaped loop external to said housing, the legs of said U-shaped loop leading into said housing, said housing having apertures through which connecting portion of said flexible tube remote from said U-shaped loop have been threaded from the interior to the exterior of said housing.

By using a continuous tube, there are no junctions or connections to different pieces of tubing, simplifying manufacture and providing a smooth flow path without sharp edges, e.g., so as to reduce the chance of damage to blood components.

In preferred embodiments there are at least three apertures in the cartridge housing, permitting the same cartridge housing and tube to be used to provide cartridges with connecting tube portions in different orientations; the apertures are provided by slots through which the tube portions can be easily and removably threaded; the housing has opposing sidewalls that define a space between them for receiving a locating plate of a carriage on which the cartridge is mounted; the housing has tabs adapted to be releasably engaged by a latching mechanism of the carriage; and the continuous tube is part of a disposable tube set, and

The invention is hereinafter more particularly described by way of example only with reference to the accompanying drawings, in which:-

Fig. 1 is a perspective view of a front panel of a blood separation machine including a rotor and race for receiving a flexible tube portion carried by an embodiment of cartridge constructed according to the present invention in order to provide a peristaltic pump;

Fig. 2 is a perspective view of an embodiment of a cartridge in accordance with the present invention for mounting on the Fig. 1 machine and carrying tube portions for use in the peristaltic pump;

Fig. 3 is a bottom view of the Fig. 2 cartridge;

Fig. 4 is a bottom view of an alternative cartridge also in accordance with the present invention having tubes threaded in a different way than the Fig. 2 cartridge;

Fig. 5 is a perspective view showing a portion of the Fig. 4 cartridge being loaded into a tube pumping region between a race and rotor of the Fig. 1 machine;

Fig. 6 is a partial vertical sectional view taken at 6-6 of Fig. 1 when a cartridge is mounted on the apparatus; and

Fig. 7 is an exploded perspective view of a race and rotor of the Fig. 1 machine.

Referring to Fig. 1, there is shown centrifugal blood separation machine 10, including on its front face

12 two peristaltic pump units 14, 16 and various other components for interacting with components of a disposable tubing set (not shown) mounted on it, for example, platelet sensor 18, red blood cell return pinch valve 20, and 3-way plasma and collect pinch valves 22, 24. Pump units 14, 16 each includes a respective carriage 26, 27 for releasably engaging a respective cartridge 34, 54 (Figs. 2, 4). Associated with, and on opposite sides of, each cartridge 34, 54 are two rotors 28 and corresponding races 30 defining tube pumping regions 32 therebetween for receiving U-shaped tube loops of the cartridges.

Referring to Fig. 2, there is shown cartridge 34, which is used with pump unit 14. Cartridge 34 includes plastic housing 36 and portions of two flexible tubes, anticoagulant tube 38 and blood inflow tube 40. These tubes are threaded through and supported within shell 36 and include U-shaped loops 42, 44 extending from opposite sides. Housing 36 includes four laterally extending curved guide supports 46 to which tubes 38, 44 are solvent bonded. Supports 46 maintain the tube portions between them in U-shaped loops. Housing 36 includes six slots 48, three at top wall 50 and three at bottom wall 52. In cartridge 34, one end of tube 38 extends upward from top wall 50 and is connected to a bag of anticoagulant (not shown) and the other end extends downward for joining with blood inflow tube 40 upstream of pump unit 14. Both ends of tube 40 extend from bottom wall 52 of housing 36. Pump cartridge 54, used with pump unit 16, employs an identical housing 36, but has a different tube arrangement; platelet tube 58 and plasma tube 56 each enter housing 36 through slots in the bottom wall and pass through respective slots in the top wall of housing 36. Both tubes 56, 58 have the

same direction of flow (top to bottom) for direction of a given rotation of rotors, even though the loops extend in opposite direction, because loop 58 overlaps itself. Slots 48 include aperture 60, large enough to hold a connecting portion of a tube therein without deformation of the tube, and narrow neck 62, which leads to aperture 60 and requires deformation of the tube when the tube passes through it. Top wall 50 and bottom wall 52 of housing 36 include tabs 64, for engaging recesses on carriage 26 in lower portion 65 and recesses in movable top portion 66. Side walls 68 of housing 36 extend downward further than top and bottom walls 50, 52 and are sized to mate with the outside surfaces of base plate 70 of carriage 26 (Fig. 6).

Referring to Figs. 5, 6, and 7, it is seen that rotor 28 includes cap 72 having radially extending tab 74 outside of tube pumping region 32. In Fig. 6, tab 74 is shown in phantom and rotated 90° from its true position with respect to rollers 84 (as can be seen from Fig. 7). Cap 72 also has four outwardly curved ribs 76, making cap 72 substantially dome-shaped. Carriage base 70 is connected for vertical movement to linear actuator shaft 78. Referring to Fig. 7, rotor 28 includes base 80 and a pair of pivotally mounted yokes 82 for rotatably supporting rollers 84 about shafts 86. Yokes 82 are pivotally mounted at ears 88 of base 80 via pins 90. Cap 72 is secured to ears 92 of base 80 via screws 94. Yokes 82 are spring biased radially outward via compression springs 96 and are prevented from unlimited outward travel via stop screws 98. Variable speed motor 100 includes motor adapter shaft 102, which passes vertically through vertical hole 108 of base 80 and has a bayonet-type slot 104 for releasably engaging pin 106,

which is secured to base 80 and passes through hole 108. Compression spring 110 is between cap 72 and plate 111, which rests on the top of adapter shaft 102. Spring 110 biases base 80 upward, thereby locking pin 106 in vertically directed end 114 of bayonet slot 104. Each roller 84 has 0.50"/1.27 cm high and 0.480"/1.2192 cm diameter cylindrical large diameter portion 116 and 0.360"/0.9144 cm to 0.365"/0.9271 cm high conical smaller diameter portion 118 having a 4° ± 30' angle and ending at a diameter of 0.429"/1.08966 cm at its top. Tab 74 extends outward from cap 72 (which is 1.80"/4.57 cm in diameter) by 0.100"/0.254 cm. Inner surface 120 of race 30 includes a large diameter portion 122 and a conical small diameter portion 124 having a similar shape to roller 84.

In operation, a disposable tubing set including cartridge 34 and cartridge 54 is mounted on machine 12, the mounting including snapping cartridge 34 onto carriage 27 of pump unit 14 and snapping cartridge 54 onto carriage 26 of pump unit 16, the tabs 64 engaging respective recesses at bottom 65 and top 66 of carriages 26, 27. U-shaped tube loops 42, 44 are initially outward of tab 74 (i.e., above tab 74 in Fig. 6), linear actuator shaft 78 being raised upward in an initial preloading position. U-shaped tube loops 42, 44 are loaded into pump units 14, 16 by rotation of rotors 28 and movement toward the face of machine 12 of linear actuater shaft 78. As tube loops 42, 44, are moved toward the face of machine 12, the curved portions of the loops are guided by dome-shaped ribs 76 and eventually move into the path of travel of tabs 74 and are engaged by them and displaced toward tube pumping region 32 between the rollers and the race as shown in Fig. 5. The tube is brought into contact with conical

small diameter portion 118 of roller 84, and then travels along the surface of conical portion 118 toward the larger diameter base of conical portion 118 and self-aligns at large diameter portion 116, owing to the difference in radius of the portions of the rollers, as linear actuator continues downward to the position shown in Fig. 6. Tube loops 42, 44 maintain their aligned positions at large diameter portions 116 of rollers 84. Because a continuous tube is used, there are no junctions or connections to different pieces of tubing, simplifying manufacture and providing a smooth flow path without sharp edges for the blood and separated blood components, reducing chance of damage to blood components.

To unload tube loops 42, 44, rotor 28 rotates while linear actuator 78 moves the cartridge outward from the front panel of the machine. The straight leg portions of U-shaped tube loops 42, 44 thus also tend to be pulled outward, while the portions engaged by the roller tend to be maintained at the large diameter portion. Eventually each tab 74 engages a respective lower surface of tube loop 42 or 44 near the junction of the straight leg portion with the portion engaged by the rollers and lifts it up outward, preventing engagement by the following roller.

CLAIMS:

1. A peristaltic pump cartridge comprising: a continuous flexible tube having two ends and a portion therebetween providing a U-shaped loop for use with a rotor and rollers to provide a peristaltic pump, a cartridge housing having supports for maintaining said portion of said flexible tube in said U-shaped loop external to said housing, the legs of said U-shaped loop leading into said housing, said housing having apertures through which connecting portion of said flexible tube remote from said U-shaped loop have been threaded from the interior to the exterior of said housing.

2. A cartridge according to Claim 1, wherein said housing has at least three apertures, permitting the same cartridge housing and tube to be used to provide cartridges with connecting tube portions in different orientations.

3. A cartridge according to Claim 2, wherein said housing has a plurality of walls, and said apertures are in at least two said walls.

4. A cartridge according to Claim 3, wherein said apertures are in two opposing walls.

5. A cartridge according to Claim 1, wherein said housing comprises a plurality of sidewalls, and said apertures comprise slots in at least one said sidewall permitting said connecting tube portions to be easily and removably threaded in said housing by moving said connecting tube portions in a direction parallel to the plane of said one sidewall.

6. A cartridge according to Claim 5, wherein said slotted apertures each include a narrow passage, whereby said flexible connecting tube portion must be deformed to permit passage of said connecting tube portion through said slotted aperture.

7. A cartridge according to any preceding claim, wherein said housing has supports for simultaneously maintaining portions of two flexible tubes in U-shaped loops external to said housing.

8. A cartridge according to Claim 7, including a second said flexible tube maintained in a U-shaped loop, wherein the two said U-shaped loops are on opposite sides of said housing.

9. A cartridge according to Claim 7, including a second said flexible tube maintained in a U-shaped tube, wherein said housing has at least five apertures, whereby the connecting portions of said flexible tubes remote from said U-shaped loops may be selectively threaded through varying combinations of apertures, permitting alignment of said remote portions with equipment external to said cartridge.

10. A cartridge according to Claim 9, wherein said housing has apertures on opposite sides.

11. A cartridge according to any preceding claim, wherein said housing comprises a pair of opposing sidewalls defining a space therebetween adapted to receive a locating plate of a carriage on which said cartridge is operatively mounted.

12. A cartridge according to any preceding claim, wherein said housing comprises tabs adapted to be releasably engaged by a latching mechanism of a carriage on which said cartridge is operatively mounted.

13. A cartridge according to Claim 12, wherein said housing comprises a pair of opposing sidewalls on which said tabs are located.

14. A peristaltic pump comprising a cartridge according to any preceding claim, and a carriage adapted to releasably engage said housing, a rotor carrying rollers and a race defining a tube pumping region

therebetween and positioned with respect to said carriage so as to receive said U-shaped loop in said tube pumping region.

15. A pump according to Claim 14 comprising a cartridge according to Claim 2 or any claim appendant thereto, wherein said continuous tube is part of a tube set, and further comprising equipment for receiving portions of said tube set, said equipment being aligned with said apertures.

16. A peristaltic pump cartridge substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

17. A peristaltic pump substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

Published 1988 at The Patent Office, State House, 66/71 High Holborn, London WC1R 4TP. Further copies may be obtained from The Patent Office, Sales Branch, St Mary Cray, Orpington, Kent BR5 3RD. Printed by Multiplex techniques ltd, St Mary Cray, Kent. Con. 1/87.